Short Communication

Suppression of *Amblyomma americanum* (Ixodida: Ixodidae) for Short-Term Field Operations Utilizing Cypermethrin and Lambda-Cyhalothrin

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ABSTRACT Tick-borne diseases pose significant risks to U.S. military personnel who conduct operations, both domestic and abroad. To determine the feasibility of protecting personnel from tick vectors during short-term field deployments, acaricides cypermethrin (Demon WP, Syngenta, Greensboro, NC) and lambda-cyhalothrin (Surrender Pestabs, CSI, Pasadena, TX) were applied to plots within two separate field sites on Camp Blanding Joint Training Center in Starke, FL, from May to June 2011. We analyzed their effectiveness in reducing tick counts for 6 wk after application. In total, 8,193 ticks were identified and counted, of which >99% were a mix of nymphs and adult-stage *Amblyomma americanum* (L.). Our results indicate that both cypermethrin and lambda-cyhalothrin were effective in significantly reducing tick numbers and preventing entry into treated plots for 6 wk after application. Thus, these two acaracides can be used to effectively suppress tick populations and provide residual protection in small geographic areas of recreation or public health significance.

KEY WORDS *Amblyomma americanum*, cypermethrin, lambda-cyhalothrin, military

In many parts of the world, tick-borne diseases pose a threat to public health. Because U.S. military personnel conduct operations around the world, their risk of exposure to vectors such as ticks and their associated pathogens is high. At military training centers in the United States, *Ixodes scapularis* Say and *Amblyomma americanum* (L.) are commonly encountered tick species. Collectively, these ticks are known to transmit the pathogens causing Lyme disease, human granulocytic anaplasmosis, human babesiosis, ehrlichiosis, and spotted fever (Centers for Disease Control and Prevention [CDC] 2013a). In 2011, there were 33,097 recorded cases of Lyme disease across the United States, and from 2003 to 2012, there were >6,300 Lyme disease–related healthcare visits among the Department of Defense active duty service members (CDC 2013b, Defense Medical Epidemiology Database [DMED] 2013). In addition to Lyme disease clinical visits, there were almost 1,000 visits related to other tick-borne illnesses (DMED 2013). To counter the risk of time lost in duty, mission degradation, and threat to public health, military preventive medicine personnel may be required to control tick populations with the use of acaricides.

There are several methods of tick control that may be used to reduce tick populations (Stafford 2007). Host reduction, host exclusion (Bloemer et al. 1990, Deblinger et al. 1993), habitat management (Bloemer et al. 1990, Mather et al. 1993, Brei et al. 2009), and host-targeted acaricide treatments (Mount 1981, Bloemer et al. 1990, Brei et al. 2009) have been shown to lower tick populations. One of the most common methods of tick control is the direct application of acaricides to a tick-infested area. Populations of *A. americanum* in wooded and recreational areas (Mount and Whitney 1984) and populations of *I. scapularis* in wooded and residential areas were shown to be reduced following a single treatment with various acaricide formulations (Schulze et al. 1994, 2000). Reducing the abundance of ticks or suppressing their biting activity with the use of personal repellents can also help reduce risks of tick-borne disease transmission (Dolan and Panella 2011).

Depending on locality and seasonality, ticks may become a problem during military field operations. In

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14. ABSTRACT
Tick-borne diseases pose signi?cant risks to U.S. military personnel who conduct operations, both domestic and abroad. To determine the feasibility of protecting personnel from tick vectors during short-term ?eld deployments, acaricides cypermethrin(DemonWP,Syngenta, Greensboro NC) and lambda-cyhalothrin (Surrender Pestabs, CSI, Pasadena, TX) were applied to plots within two separate ?eld sites on Camp Blanding Joint Training Center in Starke, FL, from May to June 2011. We analyzed their effectiveness in reducing tick counts for 6 wk after application. In total 8,193 ticks were identi?ed and counted, of which 99% were a mix of nymphs and adult-stage Amblyomma americanum (L.). Our results indicate that both cypermethrin and lambda-cyhalothrin were effective in signi?cantly reducing tick numbers and preventing entry into treated plots for 6 wk after application. Thus, these two acaracides can be used to effectively suppress tick populations and provide residual protection in small geographic areas of recreation or public health signi?cance.

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cases where operations are of short duration (<1 mo), a single application of an acaricide might lower tick populations, which would reduce the risk of pathogen transmission. Large, area-wide applications of acaricides, where field operations are conducted over longer periods, are not feasible owing to environmental risk and expense. However, the protection of small areas such as bivouac sites could be achieved by applying pesticides as a barrier treatment or as a small area application. Similarly, during disease outbreaks, this method may be used in small civilian areas such as parks and campgrounds, where recreational exposure to ticks and associated pathogens is high. The objective of this study was to determine if a commercially available wettable powder and a water-soluble pesticide were effective at reducing tick numbers in a small area over a 6-wk period.

Materials and Methods

The study was conducted over an 8-wk period from 4 May to 22 June 2011, at Camp Blanding Joint Training Center, Starke, FL (29° 56.746 N, 081° 57.246 W). This training facility hosts National Guard, Active and Reserve military units from across the country, and military trainees from allied countries.

In an area of Camp Blanding Joint Training Center that sees frequent field training activities and reports of high tick activity, two grids (~42 by 42 m) were established that contained a mix of open grasses and dense brush. Each grid was evenly divided into 49 plots, with each plot being ~6 by 6 m. Five plots within each grid were randomly selected for acaracidal treatment. After 2 wk of tick sampling, five plots in grid 1 were treated with the cypermethrin formulation (Demon WP, Syngenta, Greensboro, NC) at the label rate of one scoop (9.5 g) in 1.9 liters of water, delivering ~100 mg a.i./m^2. Five plots in grid 2 were treated with the lambda-cyhalothrin formulation (Surrender Pestabs, CSI, Pasadena, TX) in a 5.6 gram per tablet at the label rate of one tablet in 1.9 liters of water, delivering ~15 mg a.i./m^2. Hand pump compression sprayers were used to apply the acaricides.

Weekly surveillance was conducted over an 8-wk period in each grid by placing a 1-m^2 white cloth with ~85 g of dry ice in the center of each of the 49 plots. Cloths were inspected 1 hr after placement, and any ticks found on the cloths were counted and released back into the plot so as to not diminish the population. Sampling was conducted for 2 wk before pesticide application in all 49 plots in each grid to establish an untreated baseline number of ticks in each plot and totals for each grid.

Pretreatment and posttreatment abundance of *A. americanum* was compared using one-way Kruskal–Wallis tests (Zar 1999), two-sample *t*-tests, or Mann–Whitney analysis. All statistical analyses were conducted using Intel Visual Fortran Compiler XE 2013 (Fortran 2013).

Results

In total, 8,193 ticks were counted during the study (grid 1, n = 3,102, and grid 2, n = 5,091). Ticks were sight identified to species and recorded as either a nymph or an adult. All recorded ticks were determined to be *A. americanum*, with the exception of three individual *Dermacentor variabilis* (Say).

During the study period, daily temperatures for May and June ranged from a low of 6°C to a high of 36°C. The mean temperature for May was 22°C and for June was 26°C. During the study period, <4 cm of precipitation was recorded. Therefore, rainfall was not considered in the statistical analysis.

Based on power analysis, the sample sizes in this study were statistically adequate. For the statistical analysis, neighboring plot effects were accounted for by randomly choosing (from the 7 by 7 grid of 49 plots) five treated sites that are at least two plots separated from any other previously chosen treated sites to ensure that each treated plot is sufficiently spatially separated from the other treated plots (i.e., the treated plots do not share common borders with each other).

The results of the Mann–Whitney test and *t*-tests were in general agreement with those of the one-way Kruskal–Wallis test. The majority of tests showed no significant difference between the two grids for counts of nymphs, adults, and ticks overall. However, there was a significant difference between the treated and untreated plots and a significant difference among weeks and between pretreatment and posttreatment periods (Table 1). In addition, counts of nymphs, adults, and ticks were generally (significantly or insignificantly) lower for cypermethrin than for lambda-cyhalothrin (Table 1).

Discussion

One application of cypermethrin or lambda-cyhalothrin quickly suppressed tick populations in the grassy brushwood ecosystem at Camp Blanding, FL, and prevented tick entry into the treated plots, giving sustained residual control for 6 wk after treatment. Although the tick populations in untreated plots of both study grids declined over the 8-wk sampling period, presumably for seasonal reasons, we achieved significant control in the treated versus untreated plots.

These acaricides were chosen based on their known effectiveness against arthropods, dry formulation for convenient military portability, ease of use, and operational safety. Both of these branded pesticide products are registered by the Environmental Protection Agency for such applications in the United States, are on the Standard and Contingency Pesticides Lists of the Armed Forces Pest Management Board <www.afpmb.org> of the U.S. Department of Defense, and are often used by the U.S. military preventive medicine teams on deployments for general pest control operations. These particular commercial products, as formulated, are not included in the Tick Management Handbook (Stafford 2007).

Table 1. Host-seeking *A. americanum* abundance at treated and untreated plots, Camp Blanding, FL, 2011

Location	Pretreatment	Posttreatment	Kruskal–Wallis (H) or ANOVA (F) test results[a,b]	
Cypermethrin[c]				
Adults				
Untreated plots	6.0000 ± 0.4472b	3.5667 ± 0.7238a	H (6, 28) = 10.9197, P = 0.0929	F (1, 8) = 8.1796, P = 0.0225
Treated plots	2.0000 ± 3.6297b	0.0000 ± 0.0000a	H (6, 28) = 33.7557, P < 0.0001	H (1, 8) = 7.8125, P = 0.0053
Nymphs				
Untreated plots	6.0000 ± 1.0488a	4.0333 ± 1.3306a	H (6, 28) = 15.5266, P = 0.0182	F (1, 8) = 1.3474, P = 0.2650
Treated plots	5.5000 ± 1.2450b	0.0000 ± 0.0745a	H (6, 28) = 29.8149, P < 0.0001	H (1, 8) = 7.3052, P = 0.0073
Lambda-cyhalothrin[c]				
Adults				
Untreated plots	11.1000 ± 2.0761a	8.5333 ± 1.0171a	H (6, 28) = 14.7774, P = 0.0229	F (1, 8) = 1.2326, P = 0.2740
Treated plots	6.5000 ± 3.9937b	0.0000 ± 0.0000a	H (6, 28) = 33.7429, P < 0.0001	H (1, 8) = 7.7586, P = 0.0055
Nymphs				
Untreated plots	16.5000 ± 10.8397a	6.6667 ± 6.6391a	H (6, 28) = 12.5928, P = 0.0500	H (1, 8) = 1.8436, P = 0.1935
Treated plots	13.5000 ± 7.6240b	0.0000 ± 0.2173a	H (6, 28) = 26.7748, P < 0.0001	H (1, 8) = 6.9876, P = 0.0086

[a] For Kruskal–Wallis (H), values are median ticks collected in each plot ± SD, n = 5 for all comparisons.
[b] For ANOVA (F), values are mean ticks collected in each plot ± SE, n = 5 for all comparisons.
[c] Means or Medians in the same row followed by the same letter are not significantly different.

These synthetic pyrethroids could be useful for focused suppression or exclusion of ticks in small areas, such as around camp sites, for at least 6 wk, and a successful treatment program could be alternated with novel pesticides with perhaps less environmental impacts and resistance issues. Recently, the plant-derived insecticide nootkatone was evaluated in a New Jersey woodland (Dolan et al. 2009) and fungal pathogens for *I. scapularis* control in Connecticut (Bharadwaj et al. 2012). After promising results in New Jersey, treatments over a 3-yr period in Connecticut resulted in little or no control beyond the first week in all trials except when a lignin-encapsulated formulation of nookatone was tested, which provided complete suppression of tick populations for 8 wk (Bharadwaj et al. 2012). If properly formulated and tested, new nonsynthetic pesticides may allow reduced reliance on commonly used pyrethroids. Further research is warranted, given these preliminary observations.

Endemic and emerging tick-borne diseases will continue to pose a threat not only to U.S. personnel training in the field but also to a majority of the population in the United States (Cohen et al. 2009). Public health professionals across the United States and in other countries could use these results to attempt targeted tick control during disease outbreaks. Further studies should be conducted to determine if targeted applications of pesticides can suppress pathogen transmission. This study demonstrated the utility of two currently registered pyrethroid acaricides in significantly reducing the abundance of woodland ticks for up to 6 wk in small geographical areas, as might be used by military personnel on short deployments or for recreational purposes by civilians.

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References Cited

Bharadwaj, A., K. C. Stafford III, and R. W. Behle. 2012. Efficacy and environmental persistence of nootkatone for the control of the blacklegged tick (Acari: Ixodidae) in residential landscapes. J. Med. Entomol. 49: 1035–1044.

Bloemer, S. R., G. A. Mount, T. A. Morris, R. H. Zimmerman, D. R. Barnard, and E. L. Snoddy. 1990. Management of lone star ticks (Acari: Ixodidae) in recreational areas with acaricide applications, vegetative management, and exclusion of white-tailed deer. J. Med. Entomol. 27: 543–550.

Brei, B., J. S. Brownstein, J. E. George, J. M. Pound, J. A. Miller, T. J. Daniels, R. C. Falco, K. C. Stafford III, T. L. Schulze, T. N. Mather, et al. 2009. Evaluation of the United States Department of Agriculture northeast area-wide tick control project by meta-analysis. Vector Borne Zoonotic Dis. 9: 423–430.

[CDC] Centers for Disease Control and Prevention. 2013a. Tickborne diseases of the United States. A reference manual for healthcare providers. (http://www.cdc.gov/ticks/) (accessed September 2013).

[CDC] Centers for Disease Control and Prevention. 2013b. Lyme disease data. (http://www.cdc.gov/lyme/stats/index.html) (accessed June 2013).

Cohen, S. B., M. J. Yabsley, L. E. Garrison, J. D. Freye, B. G. Dunlap, J. R. Dunn, D. G. Mead, T. F. Jones, and A. C. Moncayo. 2009. *Rickettsia parkeri* in *Amblyomma americanum* ticks, Tennessee and Georgia, USA. Emerg. Infect. Dis. 15: 1471–1473.

Deblinger, R. D., M. L. Wilson, D. W. Rimmer, and A. Spielman. 1993. Reduced abundance of immature *Ixodes dammini* (Acari: Ixodidae) following incremental removal of deer. J. Med. Entomol. 30: 144–150.

[DMED] Defense Medical Epidemiology Database. 2013. Defense Medical Epidemiology Database. (http://www.afhsc.mil/aboutDmed?clear) (accessed June 2013).

Dolan, M. C., and N. A. Panella. 2011. A review of arthropod repellents, pp. 1–19. *In* G. E. Paluch and J. R. Coats (eds.), Recent developments in invertebrate repellents. ACS Symposium Series, American Chemical Society, Washington, DC.

Dolan, M. C., R. A. Jordan, T. L. Schulze, C. J. Schulze, M. C. Manning, D. Ruffolo, J. P. Schmidt, J. Piesman, and J. J. Karchesy. 2009. Ability of two natural products, nootkatone and carvacrol, to suppress *Ixodes scapularis* and *Amblyomma americanum* (Acari: Ixodidae) in a Lyme disease endemic area of New Jersey. J. Econ. Entomol. 102: 2316–2324.

Fortran Software. 2013. Visual fortran compiler XE 13.0.1.119. Intel, Santa Clara, CA.

Mather, T. N., D. C. Duffy, and S. R. Campbell. 1993. An unexpected result from burning vegetation to reduce Lyme disease transmission risks. J. Med. Entomol. 30: 642–645.

Mount, G. A. 1981. *Amblyomma americanum:* area control of over-wintered nymphs and adults in Oklahoma with acaricides. J. Econ. Entomol. 74: 24–26.

Mount, G. A., and R. W. Whitney. 1984. Ultralow-volume mists of chlorpyrifos from a tractor-mounted blower for area control of the lone star tick (Acari: Ixodidae). J. Econ. Entomol. 77: 1219–1223.

Schulze, T. L., R. A. Jordan, L. M. Vasvary, M. S. Chomsky, D. C. Shaw, M. A. Meddis, R. C. Taylor, and J. Piesman. 1994. Suppression of *Ixodes scapularis* (Acari: Ixodidae) nymphs in a large residential community. J. Med. Entomol. 31: 206–211.

Schulze, T. L., R. A. Jordan, and R. W. Hung. 2000. Effects of granular carbaryl application on sympatric populations of *Ixodes scapularis* and *Amblyomma americanum* (Acari: Ixodidae) nymphs. J. Med. Entomol. 37: 121–125.

Stafford, K. C., III. 2007. Tick management handbook: an integrated guide for homeowners, pest control operators, and public health officials for the prevention of tick-associated disease. Bull. No. 1010. Connecticut Agricultural Experiment Station, New Haven.

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